B737NG Alerting Issues – Air data system failure

1. Initiating Condition: Blocked pitot source (captain's or left source)

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	IAS DISAGREE displayed in amber under respective mach/airspeed (MASI) indicator	Variance of >5 knots for >5 seconds between Captain and F/O airspeed values	Resolution of the discrepancy requires effortful reference to standby airspeed display and/or to pitch/power displays; Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed display may appear valid and the process of identifying the discrepant display(s) may require substantial time.			Decrease of airspeed variance below threshold value
	False flashing box on digital airspeed display	AOA-compensated airspeed, not g-compensated	Resolution of the discrepancy requires effortful reference to standby airspeed display and/or to pitch/power displays			
Aural Alerts	False "Airspeed Low" alert from GPWS (if installed)	Sensed airspeed value is below min maneuver speed	False warning may prompt pilots to react with control inputs that actually result in or exacerbate loss of control			
	Possible overspeed clacker warning	Indicated airspeed exceeds Vmo/Mmo, if a pilot follows a different airspeed display that is reading an incorrectly low value into a true overspeed (valid warning).	It may not immediately be evident to the pilots whether this is a true or false warning, especially in the presence of inconsistent airspeed displays			

B737NG Alerting Issues – Air data system failure

1. Initiating Condition: Blocked pitot source (captain's or left source) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Tactile Alerts	None					
Visual Cues	Displayed mach/airspeed is inconsistent with other pilot's and standby airspeed values			Indicated mach display blanks at <M.38		
	Displayed mach/airspeed is inconsistent with displayed attitude, considering phase of flight, altitude, thrust, and weight		Resolution of the discrepancy requires effortful reference to and integration of pitch/power displays, considering multiple additional factors (weight, configuration, etc.) that must be recalled from memory or looked up			
	Displayed mach/airspeed is inconsistent with FMC ground speed/winds, IRS-displayed groundspeed, flight path vector displays		Resolution of the discrepancy requires effortful reference to multiple displays on the overhead panel and FMC, both of which may require switch selections or button pushes to display the relevant data, as well as consideration of multiple additional factors (winds aloft, true airspeed correction, etc.) that must be recalled from memory or looked up			
	Displayed mach/airspeed is inconsistent with displayed AOA (if installed)		Resolution of the discrepancy requires effortful correlation of desired airspeed with AOA, as well as consideration of multiple additional factors (altitude, mach effects, etc.) that must be recalled from memory or looked up; at the very least the pilot must recall the guidance to maintain AOA at the gauge's 3:00 position			

B737NG Alerting Issues – Air data system failure

1. Initiating Condition: Blocked pitot source (captain's or left source) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Aural Cues	None					
Tactile/Somatic Cues	None					

Expected Pilot Response(s)

- Adjust airplane attitude and thrust to maintain aircraft control.
- Perform AIRSPEED UNRELIABLE procedure to identify the incorrect airspeed display, use secondary airspeed indications of flight path vector and AOA (if installed), and reference body angle/thrust values for desired performance, as required.
- RVSM altitudes no longer allowed. Hence, lower altitudes must be used which may affect fuel burn and range. Consideration for fuel stop must be considered.
- Cat II operations may be affected and destination choices may have to be altered.

Possible sources of confusion with regard to pilot response(s)

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- Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed display may appear valid and the process of identifying the discrepant display(s) may require substantial time.

B737NG Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	IAS DISAGREE displayed in amber under respective mach/airspeed (MASI) indicator while pitot sources are partially blocked, then removed as all are completely blocked and thus become consistent.	Variance of >5 knots for >5 seconds between Captain and F/O airspeed values	Understanding and reacting to this condition requires both ignoring the false airspeed displays-- which may be inconsistent, then consistent with each other-- as well as effortful reference to pitch/power displays; Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed display may appear valid and the process of identifying the discrepant display(s) may require substantial time.			
	Flashing box on digital airspeed display	AOA-compensated airspeed, not g-compensated. Warning could be triggered either as (1) a false indication due to loss of dynamic pressure input to the pitot probe or as (2) a valid indication if pilot follows a different airspeed display that is reading an incorrectly low value into a true	Resolution of the discrepancy requires effortful reference to standby airspeed display and/or to pitch/power displays			

B737NG Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
		underspeed condition.				
Visual Alerts	PLI on PFD/EADI nears/touches airplane symbol	AOA	Stall warning may be valid if aircraft enters stall condition during loss of control while following incorrect airspeed references, but may not be considered to be valid by the pilots because of simultaneously displayed conflicting (high) airspeed and overspeed warnings (due to pitot system(s) in which the ram air pressure is trapped). Resolution of the discrepancy requires effortful reference to standby airspeed display and/or to pitch/power displays; Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed display may appear valid and the process of identifying the discrepant display(s) may require substantial time			Reduction of AOA
Aural Alerts	"Airspeed Low" alert from GPWS (if installed)	Sensed airspeed value is below min maneuver speed. Warning could be triggered either as (1) a false indication due to loss of dynamic pressure input to the pitot probe or as (2) a valid indication if pilot	False warning may prompt pilots to react with control inputs that actually result in or exacerbate loss of control			

B737NG Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
		follows a different airspeed display that is reading an incorrectly low value into a true underspeed condition.				
	Overspeed clacker alert	Sensed airspeed value is greater than Vmo/Mmo. Warning could be triggered by either (1) pressure trapped in a pitot system by drain blockage and ambient pressure decrease in the climb (false warning); or (2) a pilot following a different airspeed display that is reading an incorrectly low value into a true overspeed (valid warning).	Resolution of the discrepancy requires effortful reference to standby airspeed display and/or to pitch/power displays; Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed display may appear valid and the process of identifying the discrepant display(s) may require substantial time.	False warning may prompt pilots to react with control inputs that actually result in or exacerbate loss of control; a valid warning (such as a stall warning) may not be considered to be valid by the pilots because of this alert and falsely high airspeed on at least one display		

B737NG Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
	Stick shaker (sound of)	AOA	Stall warning may be valid if aircraft enters stall condition during loss of control while following incorrect airspeed references, but may not be considered to be valid by the pilots because of simultaneously displayed conflicting (high) airspeed and overspeed warnings (due to pitot system(s) in which the ram air pressure is trapped). Resolution of the discrepancy requires effortful reference to standby airspeed display and/or to pitch/power displays; Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed display may appear valid and the process of identifying the discrepant display(s) may require substantial time			Reduction of AOA
Tactile Alerts	Stick shaker	AOA	Stall warning may be valid if aircraft enters stall condition during loss of control while following incorrect airspeed references, but may not be considered to be valid by the pilots because of simultaneously displayed conflicting (high) airspeed and overspeed warnings (due to pitot system(s) in which the ram air pressure is trapped). Resolution of the discrepancy requires effortful reference to standby airspeed display and/or to pitch/power displays; Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed display may appear valid and the			

B737NG Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/ suppressed or when cue is masked	How alert or cue is terminated
			process of identifying the discrepant display(s) may require substantial time			
Visual Cues	Displayed mach/airspeed is inconsistent with displayed attitude, considering phase of flight, altitude, thrust, and weight		Aircraft control requires effortful reference to and integration of pitch/power displays, considering multiple additional factors (weight, configuration, etc.) that must be recalled from memory or looked up			
	Displayed mach/airspeed is inconsistent with FMC ground speed/winds, IRS-displayed groundspeed, flight path vector displays		Aircraft control requires effortful reference to multiple displays on the overhead panel and FMC, both of which may require switch selections or button pushes to display the relevant data, as well as consideration of multiple additional factors (winds aloft, true airspeed correction, etc.) that must be recalled from memory or looked up			
	Displayed mach/airspeed is inconsistent with displayed AOA (if installed)		Aircraft control requires effortful correlation of airspeed and AOA, as well as consideration of multiple additional factors (altitude, mach effects, etc.) that must be recalled from memory or looked up			
Aural Cues	None					
Tactile/ Somatic Cues	Aerodynamic buffet	Actual overspeed or approach to stall	Not definitive as to cause, may suggest either high or low speed excursion			

B737NG Alerting Issues – Air data system failure

2. Initiating Condition: Blocked pitot sources (all sources blocked, first partially and inconsistently, then completely), with ram air pressure trapped in at least one pitot system during climb (e.g., blocked pitot drain) – Cont.

Expected Pilot Response(s)

- Adjust airplane attitude and thrust to maintain aircraft control.
- Perform AIRSPEED UNRELIABLE procedure to identify the incorrect airspeed displays, use secondary airspeed indications of flight path vector and AOA (if installed), and reference body angle/thrust values for desired performance.
- RVSM altitudes no longer allowed. Hence, lower altitudes must be used which may affect fuel burn and range. Consideration for fuel stop must be considered.
- Cat II operations may be affected and destination choices may have to be altered.

Possible sources of confusion with regard to pilot response(s)

- With blocked pitot input sources and ram air trapped in the pitot system, the pilot conceivably may receive high speed (clacker) and low speed (stick shaker) warnings simultaneously, which is extremely confusing, stressful, and distracting.
- If the aircraft is flown into an actual overspeed condition with all air data inputs missing or invalidly low, the expected overspeed warnings will be absent. The absence of an expected warning can be confusing and inhibit pilots' identification of the overspeed condition.
- Pilots may follow incorrect airspeed guidance into an undesired aircraft state or loss of control, because the airspeed displays may appear valid and the process of identifying the discrepant display(s) may require substantial time.

B737NG Alerting Issues – Air data system failure

3. Initiating Condition: Air data computer failure (single module or unit) – Cont.

Visual Alerts	On respective MASI the airspeed display is replaced by an amber SPD flag	Loss of source input				
	Master caution amber light	Loss of airspeed input to yaw damper system	Yaw damper failure is not the primary failure or the one demanding immediate recognition and action			
	Flight control amber annunciator light	Loss of airspeed input to yaw damper system	Yaw damper failure is not the primary failure or the one demanding immediate recognition and action			
	Yaw damper amber light on overhead panel	Loss of airspeed input to yaw damper system	Yaw damper failure is not the primary failure or the one demanding immediate recognition and action			
Aural Alerts	None					
Tactile Alerts	None					
Visual Cues	On respective MASI, airspeed cursor is removed	Loss of source input				
	On respective MASI, red/white maximum operating speed range is removed	Loss of source input for overspeed				
Aural Cues	Yaw damper switch "snap" sound"		Cue is not definitive as to cause, and also it is ambiguously similar to other sounds such as the opening of circuit breakers.			
Tactile/ Somatic Cues	None					

Expected Pilot Response(s)

- Adjust airplane attitude and thrust to maintain aircraft control.

B737NG Alerting Issues – Air data system failure

3. Initiating Condition: Air data computer failure (single module or unit) – Cont.

- Perform AIRSPEED UNRELIABLE procedure to identify the incorrect airspeed display, use secondary airspeed indications of flight path vector and AOA (if installed), and reference body angle/thrust values for desired performance, as required.
- RVSM altitudes no longer allowed. Hence, lower altitudes must be used which may affect fuel burn and range. Consideration for fuel stop must be considered.
- Cat II operations may be affected and destination choices may have to be altered.

Possible sources of confusion with regard to pilot response(s)

- Secondary alerts (e.g., yaw damper) may distract pilots from recognition of the underlying failure and immediate actions required to maintain control.